NASA TT F-10,693

N67 18935
(ACCESSION NUMBER) (THRU)
6 1
(PAGES) (CODE)
16
(NASA CR OR TMX OR AD NUMBER) (CATEGORY)

FACILITY FORM 602

NASA TT F-10,693

DRAG EFFECT OF THE ACTIVE MEDIUM OF A GAS RING LASER

Dario Pecile and Edmond Batifol

Translation of "Effet de l'entrainement du milieu actif d'un laser à gaz en anneau"
Centre National d'Etudes des Télécommunications Département "P.C.M."
Paper presented to the Academy of Sciences, 8 August 1966

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON JANUARY 1967

DRAG EFFECT OF THE ACTIVE MEDIUM OF A GAS RING LASER

Dario Pecile and Edmond Batifol

A study was made of the beat frequency F between the oscillations corresponding to the two directions of travel in a ring laser cavity, when the gas discharge column constituting the active medium was in motion. The phenomenon, involving the dispersion of the active medium, should help to explain the operation of the laser. On the other hand, the experiment affords a method for shifting the zero of a laser gyroscope. This procedure does not require the introduction of solid elements into the cavity.

I. Introduction

Recent articles have evidenced the importance of ring lasers used as gyroscopes (ref. 1). With this type of laser, very slight differences of optical lengths can be attained. We concerned ourselves with ring lasers in nonreciprocal electric polarization, i.e., the electric polarization of the active medium depends upon the direction of its travel in the cavity. /1*

II. Experimental apparatus

The experimental apparatus is a ring laser oscillating at the 1.15 μ transition of neon.

The laser cavity comprises four mirrors arranged at the corners of a 55-cm square. Three of these mirrors are flat. The fourth mirror is spherical-concave with a 5-m radius of curvature, and is diametrically opposite the beam-sampling mirror.

The recombination system comprises two reflecting mirrors and an optical separator. It leads the emergent beams corresponding to the two directions of travel in coincidence onto the cathode of a photomultiplier, having an S1 coating. The output signal is directed to a low-frequency spectrum analyzer.

The active medium is a helium-neon mixture at an average pressure of a few torr, contained in one or more tubes closed by windows at Brewster's angle and energized by an electric discharge of length 30 cm. We are able to induce a laminar flow of gas in one of the laser tubes and the velocity of the gaseous flow is determined by direct measurement of the upstream-downstream pressure /2
difference. Excitation of the whole unit is such that the laser generally oscillates in two normal modes separated by a little less than 150 MHz.

When the circulation in the laser tube has been stopped, we can introduce a difference in the optical lengths of the cavity in the direction of travel by

*Numbers given in margin indicate pagination in original foreign text.

inserting a supplementary tube in which gas or air at atmospheric pressure flows. This difference of optical lengths is expressed by a separation between the oscillation frequencies. This is the Fizeau experiment: the drag of electromagnetic waves by a substance in motion (ref. 2). We can superpose the asymmetry due to the flow of the inert gas on the asymmetry introduced by the movement of the column of active gas.

III. Results

A first series of experiments was conducted with multilayer dielectric mirrors having a maximum coefficient of reflection. The laser oscillation was maintained solely by the circulation tube. We established curves showing the beat frequency F as a function of the difference of pressure at the ends of the tube (fig. 1). On the scale of pressure differences, we applied rates of maximum drag v calculated with the assumption of a regime of laminar flow. The velocity distribution in the straight section is parabolic, but the oscillation relates to the central part of the tube, where the velocity is substantially constant.

The curves show that F is approximately proportional to v. At constant velocity v, the beat frequency F is very sensitive to cavity losses, either accidental losses such as are due to dust deposited on the windows or mirrors, or losses systematically introduced by a diaphragm or special mount. Frequency F depends rather little upon the tube discharge current in the indicated zone of operation.

With the aid of the Fizeau-effect light-drag apparatus, we observed that the direction of shift of beat frequency by the motion of the active medium is that which would be observed with a dense, nondispersive medium. There is a wave drag.

In a second series of experiments the mirrors have a lower coefficient of /3 reflection. The cavity contains one or two laser tubes without gas drag or the circulation tube. For given drag rates, we established curves of frequency F as a function of the discharge current of the circulation tube (fig. 2). The discharge current modifies the tube gain or absorption.

When the medium in circulation is an amplifier there is wave drag. When this medium is absorbent, there is a delay of the wave. When the medium in circulation is neutral, and particularly when the electric discharge is interrupted, the normal Fizeau drag should yield a frequency F much lower than the frequencies indicated in figures 1 and 2.

IV. Conclusions

The interpretation that we will publish at a later date shows the preponderant role of the attraction of the beat frequency toward the center of the line. In the first series of experiments, along the direction of travel the nearly symmetrical profiles of the line of amplification are shifted in frequency. In the second series the profiles of the line are asymmetrical and the asymmetry depends upon the direction of travel.

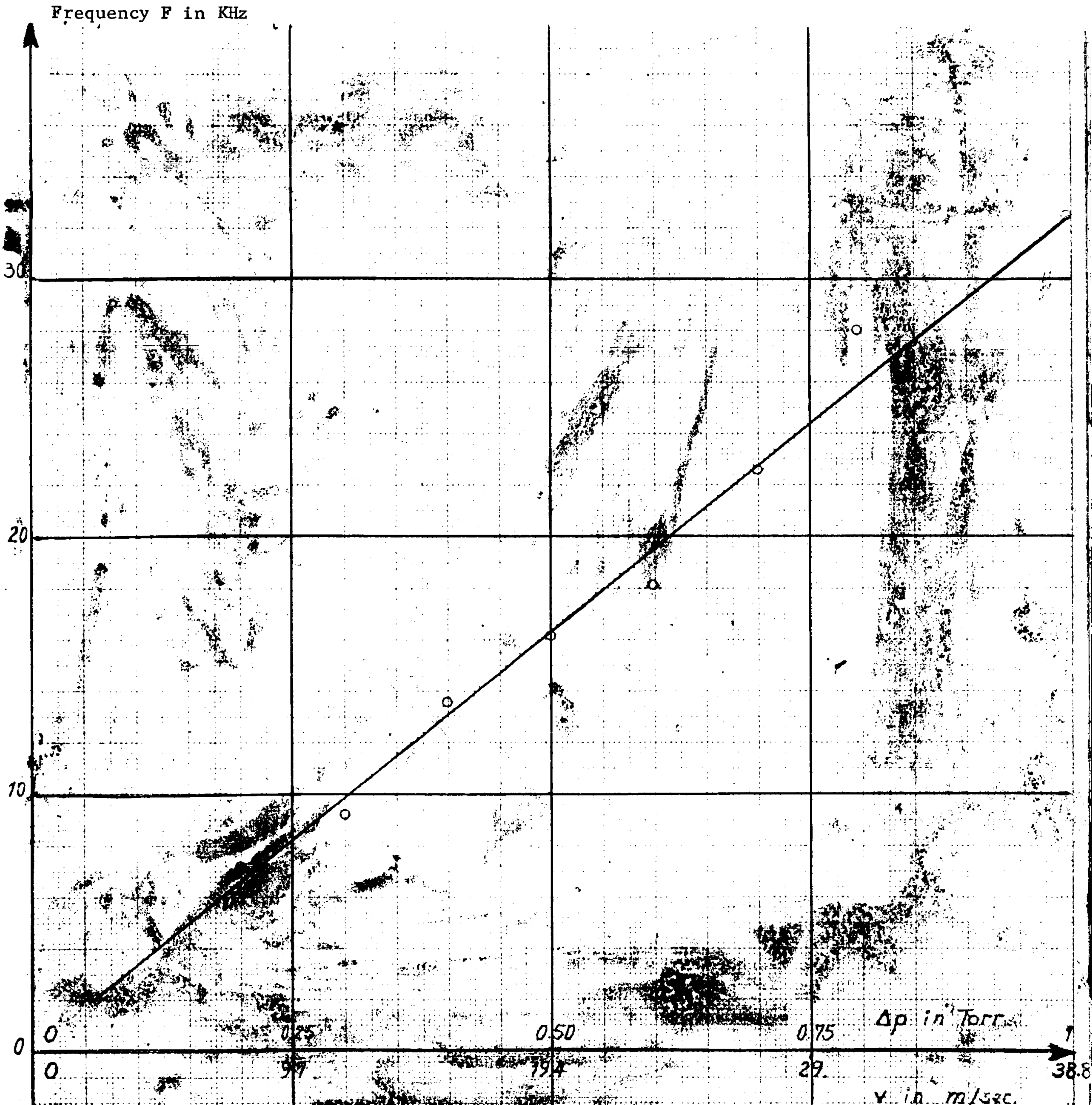
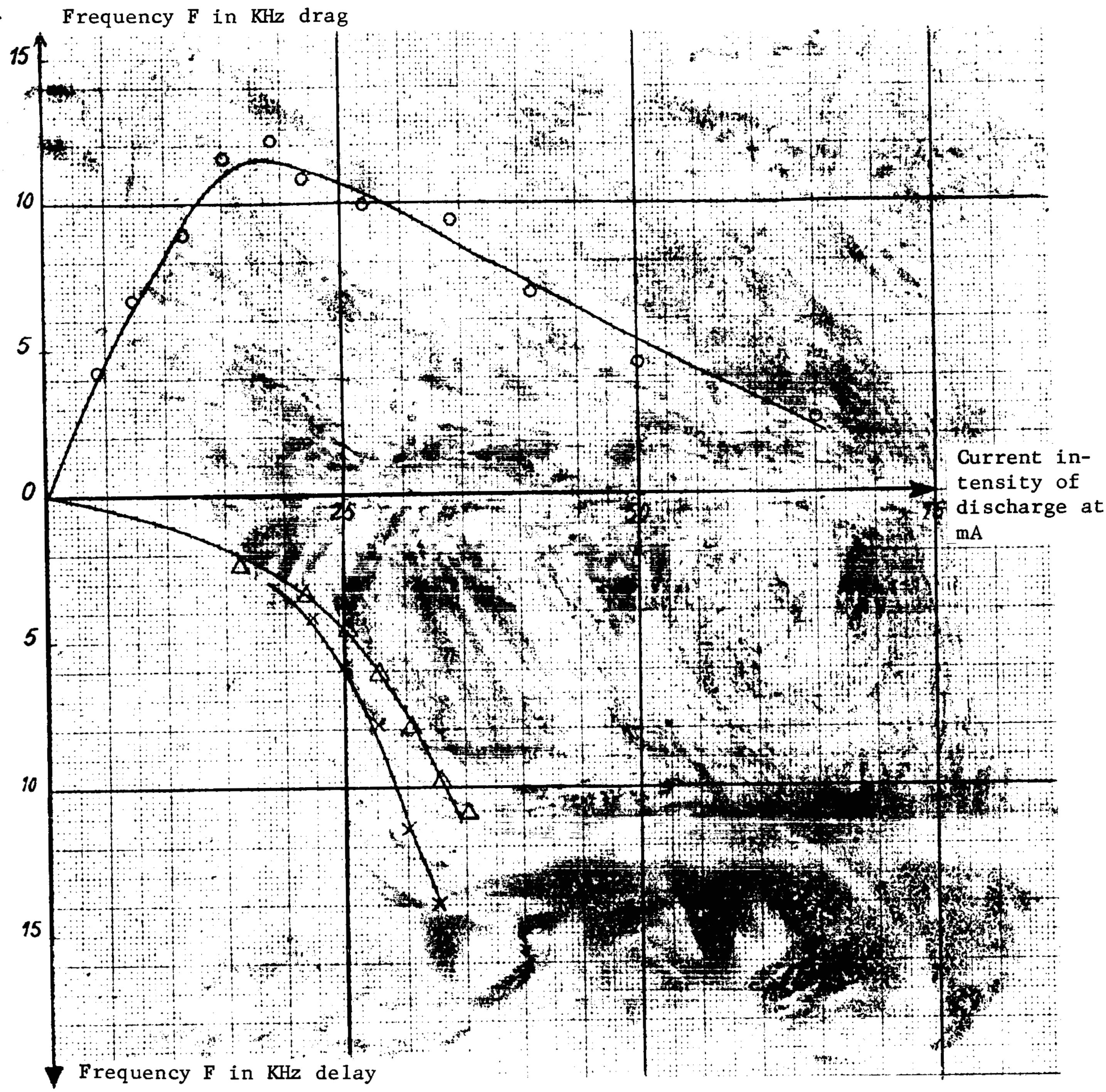


Figure 1. Tube: Internal Ø 5.35 mm, discharge length 30 cm.



o mixture He-Ne 10%, p=1.5 Torr, v=8 m/sec

X pure neon, p=1.6 Torr, v=6.6 m/sec

Δ pure neon, p=1.3 Torr, v=6.6 m/sec

Figure 2. Circulation tube: internal ϕ 5.35 mm, discharge length 30 cm.

The phenomena of attraction and repulsion of frequency in the linear gas laser have been studied, especially by the variation of the beat frequency between two adjacent normal modes as a function of the parameters of the oscillator (ref. 3). The described experimental technique allows another approach to these phenomena in addition to the indicated practical application.

REFERENCES

1. Macek, W. M. and Davis, D. T. M. Journées d'Etudes sur les gyroscopes avancés (Workshop on Sophisticated Gyroscopes). 2-6 November 1964, Appl. Phys. Letters 2, 1963, p. 67 (Mémorial de l'Artillerie Française, 2^{o} fasc. 1965).
2. Macek, W. M., Schneider, J. B. and Salamon, A. M. Journal of Appl. Phys., p. 2556, August 1964.
3. McFarlane, R. A. Phys. Rev., p. 543A, 3 August 1964.

Translated for the National Aeronautics and Space Administration by John F. Holman and Co. Inc.